Carotid bypass with polytetrafluoroethylene grafts: A study of 110 consecutive patients

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Background: **Carotid endarterectomy (CEA) is the standard treatment for atherosclerotic lesions involving the carotid bifurcation. However, CEA can be challenging under some conditions. We describe the technique and outcome of prosthetic carotid bypass grafting (PCB) with polytetrafluoroethylene (PTFE) grafts as an elective alternative to CEA.**

Patients and methods: **This retrospective analysis of prospectively collected data came from a series of 110 consecutive PCBs, that is, 9.6% of 1140 carotid revascularization procedures performed in our department between September 1986 and July 2002. Primary indications for PCB were extensive atherosclerotic lesions (n = 45, 40.9%), carotid stenosis associated with kinking (n = 29, 26.4%), recurrent stenosis (n = 18, 16.4%), and stenosis after radiation therapy (n = 7, 6.4%).**

Results: **The combined stroke and death rate at 30 days was 0.9%. Mean duration of follow-up was 647 ± 71 days. Four carotid bypass grafts (3.6%) became occluded, and stenosis recurred in 1 (0.9%). At 3 years, overall actuarial survival was 81.4 ± 11.5 and actuarial stroke-free rate was 97.7 ± 2.3. There were no fatal strokes.**

Conclusion: **PCB is a viable technique for treatment of extensive atherosclerotic carotid lesions, recurrent carotid stenosis, and carotid stenosis after radiation therapy. Postoperative stroke, occlusion, and recurrent stenosis rates are comparable to those associated with CEA performed under optimal conditions. (J Vasc Surg 2003;38:1031-8.)**

Carotid endarterectomy (CEA) is the standard treatment for atherosclerotic lesions involving the carotid bifurcation.[1-13] While well suited for treatment of most carotid stenoses, CEA can be challenging in some cases, such as extensive stenosis in the internal or common carotid artery,[14] stenosis associated with carotid kinking,[14,15] stenosis after radiation therapy, and fibrous recurrent stenosis. For these indications, carotid bypass grafting is a particularly attractive alternative to CEA, because the length of the bypass is short, flow rate is high, and the proximal and distal arteries are usually free of atherosclerotic lesions. This retrospective analysis of prospectively collected data was undertaken to document the results of elective use of prosthetic carotid bypass (PCB) with a polytetrafluoroethylene (PTFE) graft in selected indications.

METHODS

From September 1986 to July 2002, a total of 1140 carotid revascularization procedures, including 25 repeat procedures, were carried out in our vascular surgery department. In 110 of the 1140 procedures (9.6%), PCB with a PTFE graft (W. L. Gore & Associates, Flagstaff, Ariz) was performed. Mean patient age in the PCB group was 72.9 ± 9.2 years (range, 48-92 years). Degree of carotid stenosis, according to criteria of the North American Symptomatic Carotid Endarterectomy Trial,[3] is summarized in Table I, associated risk factors are shown in Table II, and neurologic symptoms are listed in Table III. The lesions were asymptomatic in 61 patients (55.4%). Symptoms included transient ischemic attack or amaurosis in 33 patients (30.1%) and minor stroke in 14 patients (12.7%).

The most common indication for PCB was extensive atherosclerotic stenosis with involvement of the common or distal internal carotid artery, in 45 patients (40.9%; Table IV). Other indications were carotid stenosis associated with kinking in 29 patients (26.4%), recurrent stenosis in 18 patients (16.3%), stenosis after radiation therapy in 7 patients (6.4%), and technical failure of CEA in 11 patients (10%). Causes of technical failure of CEA were fracture disruption of atherosclerotic plaque in the common carotid artery during clamping (n = 2), transmural atherosclerotic involvement resulting in perforation of the wall during endarterectomy (n = 5), and intimal flap of the internal carotid artery detected at completion arteriographic assessment (n = 4). Technical failure, in which PCB was the only alternative, accounted for 1% of the 1040 CEAs performed during the study.

After each procedure a file including all preoperative clinical findings and operative data was opened. This file was updated at discharge and after follow-up examinations at the end of the first month and yearly thereafter. Follow-up examination included clinical findings and color duplex scanning of the supra-aortic trunks. Recurrent stenosis was defined as any stenosis involving more than 50% of the vessel diameter,[3] with peak systolic velocity greater than 120 cm/s and either spectral broadening or end-diastolic velocity greater than 100 cm/s.[15] Statistical analysis was performed to determine survival, stroke-free, and

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Table I. Degree of carotid stenosis in 110 patients undergoing carotid bypass with PTFE grafts

Carotid stenosis (%)*	*No. of carotid arteries*	*%*
50-69	18	16.4
70-89	54	49.1
90-99	38	34.5

*Measurement of stenosis was performed according to criteria defined by North American Symptomatic Carotid Endarterectomy Trial.[3]

Table II. Main systemic and local risk factors in 110 patients with carotid stenosis treated with carotid bypass with PTFE grafts

Risk factors	*No. of patients*	*%*
Systemic		
Hypertension	76	69.1
Dyslipidemia	61	55.4
Diabetes	23	20.9
Lower extremity occlusive artery disease	11	10.1
Coronary artery disease	32*	29.1
Local		
Neck irradiation	7†	6.4
Contralateral carotid occlusion	6	5.4

*Among 32 patients with coronary artery disease, 10 underwent coronary artery bypass grafting or angioplasty.
†One patient who underwent neck irradiation had a tracheotomy.

Table III. Manifestations in 110 patients with carotid stenosis treated with carotid bypass with PTFE grafts

Neurologic symptoms	*No. of patients*	*%*
Asymptomatic	61	55.4
Transient ischemic attack	33*	30.1
Stroke	14	12.7
Vertebrobasilar insufficiency	2	1.8

*Among the 33 patients with transient ischemic attack, 11 had amaurosis.

recurrent stenosis rates, according to the Kaplan-Meier method, with calculation of the standard error.

Operative technique. The patient was placed in the usual position for CEA, with the head on a ring, face turned away from the operative side, and shoulders propped up with a sandbag. The carotid artery was exposed along the anterior border of the sternomastoid muscle, from the omohyoid to the digastric muscle. The dissection plane passed in front of the internal jugular vein. The hypoglossal nerve was located, and the descending branch was divided. Rather than dividing the digastric muscle in patients with high carotid bifurcations or extensive lesions of the internal carotid artery (n = 7), our technique consisted of dividing the descending branch of the ansa cervicalis from the hypoglossal nerve, ligating the small arterial branch tethering the hypoglossal nerve, and finally reclining the muscle upward. Ligation of the occipital artery and vein was also needed, to enhance mobilization of the hypoglossal nerve. To avert nerve injury, diathermy should not be applied to these small vessels. If atherosclerotic lesions extended to the common carotid artery, that vessel was exposed after division of the omohyoid muscle (n = 4).

Proximal anastomosis of the PTFE graft (6 mm diameter, n = 105; 8 mm diameter, n = 6) was made as follows. After systemic heparinization (50 UI/kg), the common carotid artery was clamped at the base of the neck, about 4 cm below the carotid bifurcation (Fig 1, *A*). Thus the external carotid artery and its branches continued to supply blood to the internal carotid artery during carotid occlusion in nearly 50% of cases.[16] Arteriotomy was performed on the common carotid artery, and an end-to-side anastomosis 20 mm long was made between the PTFE graft and the common carotid artery with 6-0 polypropolene (Prolene) or Gore-Tex CV8 (Gore) suture. After terminating the anastomosis, the internal carotid artery was clamped 2 to 3 cm distal to the atherosclerotic lesion (Fig 1, *B*). Any air or debris within the lumen was evacuated through the unattached end of the PTFE graft before restoring flow in the common carotid artery and external carotid artery.

Distal anastomosis of the PTFE bypass graft was made as follows. The internal carotid artery was clipped immediately distal to the atherosclerotic lesions, and a 15-mm-long arteriotomy was made on the internal carotid artery. The graft was then filled with heparin-saline solution and exposed to arterial tension to facilitate length measurement and thus avert tension or kinking. An end-to-side distal anastomosis was made between the PTFE graft and internal carotid artery (Fig 1, *C*). After flushing, the suture line was tied under pressure, and the clamp was removed from the internal carotid artery. Completion digital arteriography was performed in all cases.

Variant techniques. In 18 patients with severe common and external carotid artery stenosis (Fig 2, *A*), amputation of the origin of the internal carotid artery (Fig 2, *B*) followed by localized endarterectomy in the common and external carotid arteries was required. This was performed under direct vision, with control of the distal end point on the external carotid artery (Fig 3). The arteriotomy was closed with direct suture (n = 2) or patch angioplasty (n = 16).

In cases with extensive stenosis of the ipsilateral common carotid artery or innominate artery trunk, proximal anastomosis was performed on the ipsilateral subclavian artery (n = 1) or contralateral common carotid artery (n = 1). In cases with lesions extending high into the distal internal carotid artery, the distal internal carotid artery stump was transposed anterior to the hypoglossal nerve before anastomosis (n = 7).

A carotid shunt was used in 5 patients (4.5%). It was placed at the beginning of the procedure in the distal internal and common carotid artery.[7] To enable extraction of the shunt, the last fourth of the proximal anastomosis suture was left open. The distal anastomosis was made in similar fashion with the shunt in place. Both anastomoses were terminated after shunt removal.

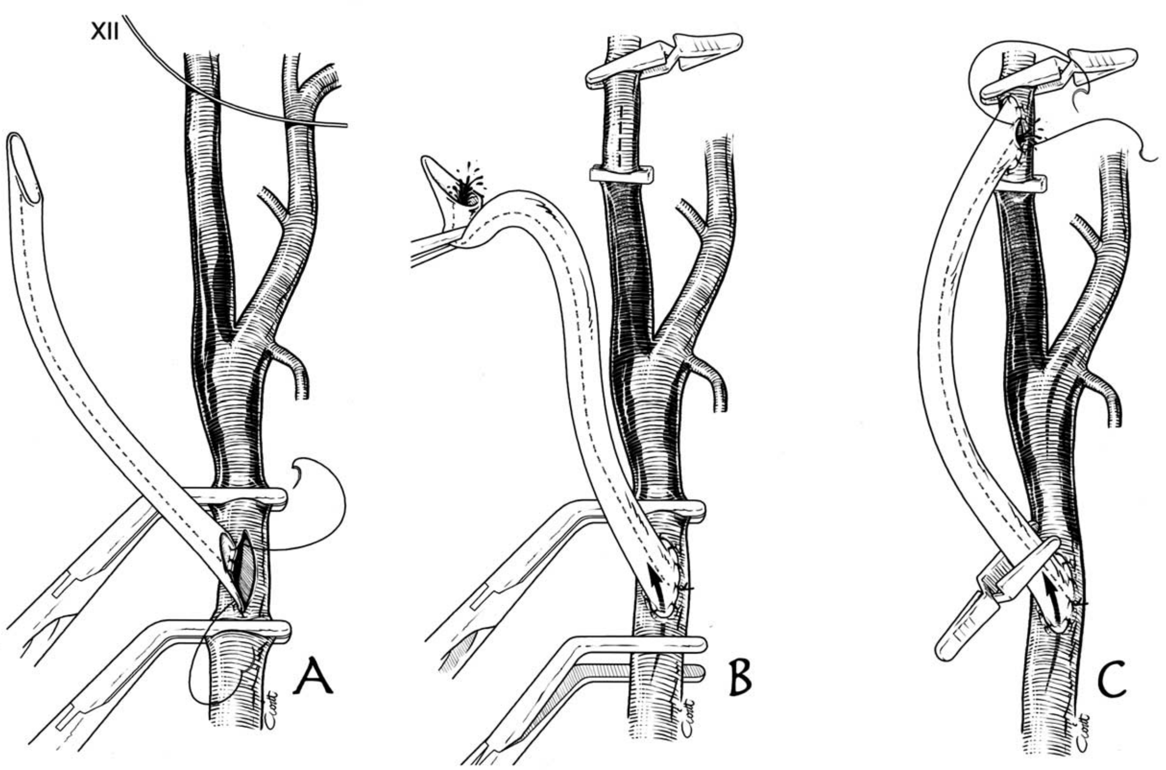

Fig 1. Proximal anastomosis of PTFE graft. **A,** After systemic heparinization (50 UI/kg), common carotid artery is clamped at base of neck, about 4 cm below carotid bifurcation. Arteriotomy is performed on common carotid artery, and end-to-side anastomosis is made between PTFE graft and common carotid artery. **B,** After terminating anastomosis, internal carotid artery is clamped 2 to 3 cm distal to atherosclerotic lesion. Any air or debris within the lumen is evacuated through unattached end of PTFE graft before restoring flow in common carotid artery and external carotid artery. **C,** Distal anastomosis of PTFE bypass graft is made as follows. Internal carotid artery is clipped immediately distal to atherosclerotic lesions, and arteriotomy is made on internal carotid artery. End-to-side distal anastomosis is made between PTFE graft and internal carotid artery. After flushing, suture line is tied under pressure, and clamp is removed from internal carotid artery.

Table IV. Indications for carotid bypass with PTFE grafts in 110 patients

Indications for carotid bypass	*No. of patients*	*%*
Extensive stenosis (common and/or internal carotid artery)	45	40.9
Stenosis associated with kinking or coiling	29	26.4
Recurrent stenosis	18	16.3
Technical failure of endarterectomy	11	10
Stenosis after radiation therapy	7	6.4

RESULTS

The combined stroke and death rate at 30 days was 0.9%. The only complication was nonfatal postoperative stroke in one patient treated because of symptomatic carotid stenosis causing amaurosis. Completion arteriograms and postoperative duplex scans in this patient demonstrated a patent, functional PCB with no defect, suggesting that embolism was the most likely cause of stroke. Postoperative mortality was nil. Postoperative complications are summarized in Table V. No systemic or prosthetic infection occurred in this series.

Mean follow-up was 647 ± 71 days. Cumulative survival was 94.7% ± 5% at 1 year and 81.4 ± 11% at 3 years (Fig 4). Follow-up color duplex scans demonstrated occlusion of 6-mm-diameter PTFE grafts in four patients, at 40 days, 109 days, 2 years, and 4 years, and recurrent stenosis greater than 50% in one patient. Three of the four patients with occlusions had no symptoms; the remaining patient, with occlusion at 4 years, had stroke. Postoperative duplex scans were normal in all four of these patients. In the patients with PTFE graft occlusion at 2 and 4 years after operation, duplex scans were normal at 1 year before oc-

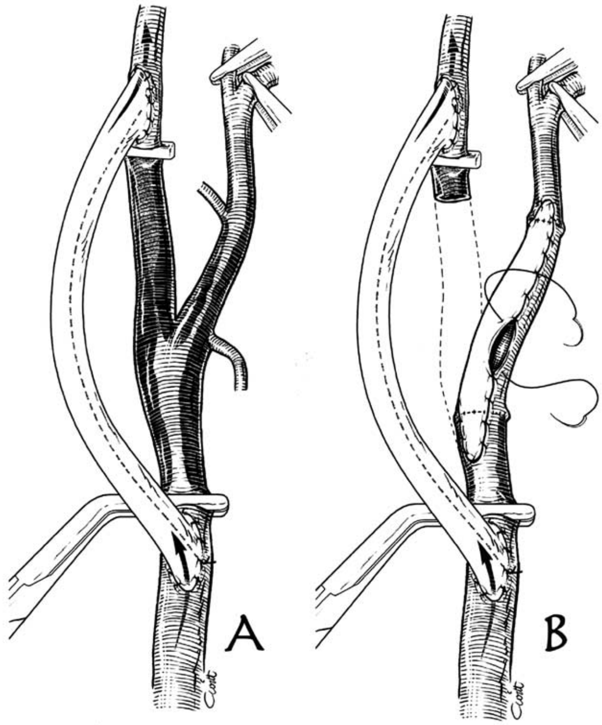

Fig 2. In severe common and external carotid artery stenosis (**A**), amputation of origin of internal carotid artery is necessary, (**B**), followed by localized endarterectomy in common and external carotid arteries. Arteriotomy is closed with direct suture.

Fig 3. Intraoperative arteriography of a prosthetic internal bypass with endarterectomy and patch of the external carotid artery, as described in Fig 2.

clusion. The cause of occlusion, thrombocytopenia, could be determined in only one patient. Turbulence due to recurrent stenosis involving less than 40% of the lumen was noted in 11 patients. These recurrent stenoses were located in the common carotid artery in 6 patients, proximal anastomosis in 4 patients, and distal anastomosis in 1 patient. All of these noncritical recurrent stenoses were stable and asymptomatic.

Primary bypass graft patency was 97.4% $\pm$ 3.5% at 1 year and 95.0% $\pm$ 5.7% at 3 years (Fig 5). Actuarial stroke-free rate was 97.7% $\pm$ 2.3% at 3 years (Fig 6). Two patients had ipsilateral stroke during follow-up, at 102 days in one patient with a patent bypass and related to occlusion of the bypass graft 4 years after the procedure in the other patient. No contralateral stroke occurred during follow-up.

DISCUSSION

This study demonstrates that PCB with PTFE grafts can be performed with a combined stroke and death rate comparable to that observed in the best CEA series.[2,3,10] This finding is in agreement with two nonrandomized comparative studies that showed no significant difference in outcome with carotid bypass grafting and CEA.[14,17] A randomized prospective study of the effectiveness of these two techniques would be meaningless, because carotid bypass grafting is indicated only under challenging conditions for CEA.

In our experience, PCB with PTFE grafts was used as an alternative to CEA in fewer than 10% of the 1140 carotid repair procedures carried out during the study. Like other French groups,[17,18] including Cormier et al,[19-21] the main proponents of the technique in France, we performed carotid bypass electively. The primary determinants for successful outcome are accurate measurement of graft length so that the distal anastomosis can be made without tension or kinking after clamp removal, creation of an end-to-side internal carotid anastomosis, and implantation of both ends of the bypass graft in nondiseased carotid arteries. Although the distal anastomosis may be made end-to-end, we prefer end-to-side anastomosis when the posterior wall of the distal internal carotid artery is thickened, because it enables creation of a larger, less technically demanding anastomosis.[14,24]

The most common indications for carotid bypass grafting are extensive atherosclerotic lesions of the common or internal carotid artery, stenosis associated with kinking, recurrent stenosis, technical failure of CEA because of presence of a major intimal flap in the internal or external carotid artery or carotid wall perforation during CEA to treat transmural atherosclerotic lesions, early occlusion after carotid endarterectomy, and atherosclerotic stenosis after radiation therapy.

Extensive atherosclerotic lesions. Regardless of the technique used, CEA to treat extensive atherosclerotic stenosis of the common carotid artery leaves a step at the proximal end of the endarterectomy. Archie[22] showed that

Table V. Early complications after carotid bypass with PTFE grafts in 110 patients

Complications	*No. of patients*	*%*
Stroke	1	0.9
Transient ischemia attack	1	0.9
Peripheral nerve paralysis	2	1.8
Cervical hematoma	1	0.9
Superficial infection	1	0.9
Myocardial infarction	1	0.9

the presence of a step greater than 2 mm could cause embolism and restenosis. Because carotid bypass grafting reduces the risk for such complications, it is especially suitable for treatment of extensive atherosclerotic lesions. Another alternative for treatment of extensive lesions of the internal carotid artery is extended open endarterectomy with patch angioplasty. However, that technique creates a long endarterectomized zone with high thrombogenic potential. In view of that drawback, prosthetic carotid bypass grafting seems to be the simplest and safest method, although it too has thrombogenic potential.

Stenosis associated with kinking or coiling of internal carotid artery. In addition to carotid bypass grafting, treatment alternatives for stenosis associated with kinking or coiling of the internal carotid artery include eversion CEA associated with either shortening of the internal carotid artery or reimplantation of the internal carotid artery on the common carotid artery.[11,15] However, use of the eversion technique is difficult in cases involving thick plaque in the common carotid artery. In this regard, most residual stenoses after eversion CEA are located in the common carotid artery.[15] CPB seems to be an acceptable alternative to eversion endarterectomy in these cases.

Recurrent carotid stenosis. Recurrent stenosis after CEA is uncommon. According to Gelabert and Moore,[23] fewer than 1.5% of patients undergoing CEA require repeat operation because of recurrent stenosis. In our experience, recurrent stenosis after CEA occurred in only 2.2% of carotid repair procedures performed, and accounted for 16.4% of carotid bypass procedures. Repeat CEA with patch angioplasty has been used to treat recurrent stenosis, especially when the lesion develops late as a result of atheromatous progression.[25] However Gagne et al[26] documented further recurrent stenosis in 20% of patients who underwent repeat CEA. In the present study no further recurrence was observed after treatment of recurrent stenosis with PTFE bypass grafts.

Prosthetic grafts appear to be more suitable than venous grafts for carotid bypass after recurrent carotid stenosis. According to Cormier et al,[20, 21] only greater saphenous vein segments 4 to 5 mm in diameter are useable, because segments smaller than 4 mm in diameter or with thick walls are prone to early thrombosis and stenosis, and segments larger than 5 mm in diameter are prone to aneurysm. In a series of 38 venous carotid bypass procedures, Berguer and Kline[27] observed two recurrent stenoses involving saphenous vein with diameter less than 4 mm. Another prerequisite feature for use of vein grafts for carotid bypass is absence of valves and collateral branches. An

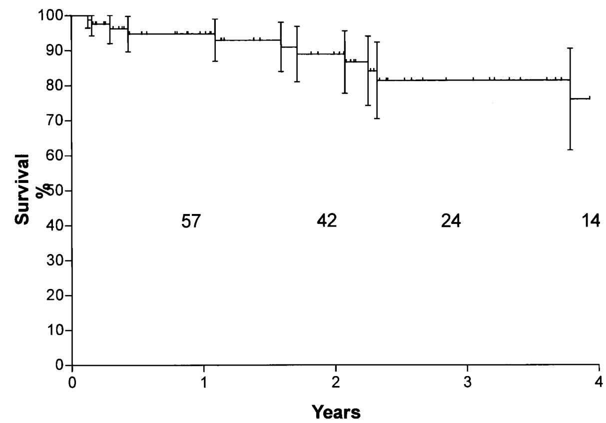

Fig 4. Cumulative survival rate with 95% confidence interval. The number of patients at risk for each interval is given. Cumulative survival rate was 81.4 ± 11% at 3 years.

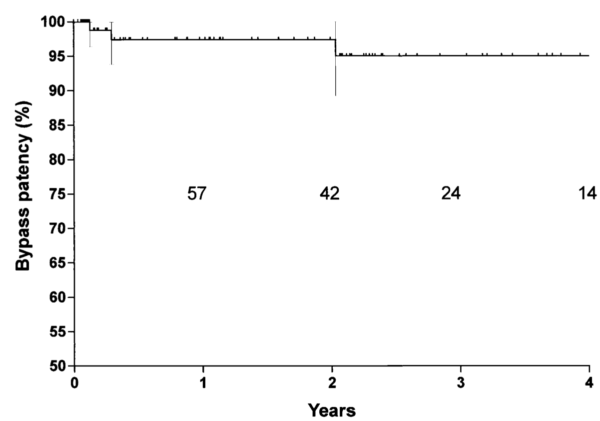

Fig 5. Bypass graft patency rate with 95% confidence interval. The number of patients at risk for each interval is given. Cumulative patency was 95.0 ± 5.7% at 3 years.

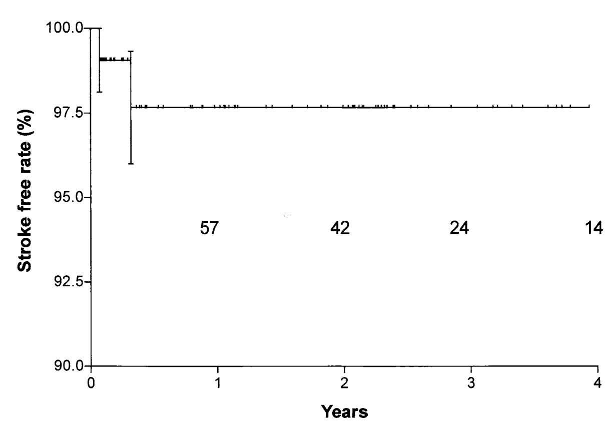

Fig 6. Kaplan-Meier stroke-free rate with 95% confidence interval. The number of patients at risk for each interval is given. Stroke-free rate was 97.7 ± 2.3% at 3 years.

added disadvantage of vein grafts is that it is necessary to harvest the greater saphenous vein at the thigh level to obtain a segment of adequate diameter. Thigh-level harvesting enhances potential for thrombosis of the remaining segment of vein and thus the likelihood that it will become unusable for future revascularization procedures.

Immediate technical failure of carotid endarterectomy. Immediate technical failure of CEA is uncommon. It occurred in only 1% of the 1040 CEA procedures performed during the study and accounted for only 10% of our indications for carotid bypass grafting. In most cases CEA failure was due either to difficulty associated with treatment of extensive lesions of the common or internal carotid artery or to perforation of artery wall during endarterectomy of transmural atherosclerotic lesions. Other causes included suture stenosis, kink-related narrowing, and distal intimal flaps after eversion endarterectomy, mandating conversion from CEA to carotid bypass grafting.[28,29]

Another situation with potential for CEA failure involves massive calcified atherosclerotic lesions of the common carotid artery extending into the external carotid artery. In these cases blind endarterectomy of the external carotid artery may lead to formation of a distal intimal flap, resulting in secondary occlusion of the external carotid artery, with risk for retrograde cerebral embolism via the internal carotid artery.[30] Carotid bypass grafting resolves this problem by dissociating revascularization of the internal carotid artery from revascularization of the external carotid artery (Fig 2), and enabling separate external carotid endarterectomy under direct vision.

Early occlusion after carotid endarterectomy. Early occlusion is uncommon after carotid endarterectomy. In patients with localized deficit without disturbance of consciousness, the consensus is that immediate repeat operation is warranted.[31] The most effective technique consists of systemic heparinization followed by opening of the carotid bifurcation to check for reflux from the internal carotid artery and carrying out PCB, unless thrombosis is extensive. Anastomoses should be placed at a sufficient distance to exclude the endarterectomized zone.

Atherosclerotic stenosis after radiation therapy. Endarterectomy is difficult in patients with atherosclerotic stenosis after radiation therapy, because atheroma is usually extensive and inflammatory. Seven of the carotid PTFE graft bypass procedures in this study were carried out after unsuccessful attempts to perform endarterectomy in patients with atherosclerotic stenosis after radiation therapy. The outcome of bypass grafting was stable in all cases. In a series of 40 carotid bypass procedures with greater saphenous vein grafts (n = 27) and PTFE grafts (n = 13) for treatment of atherosclerotic stenosis after radiation therapy, Cormier et al[19] observed one vein graft necrosis 7 days after the procedure. In our opinion, prosthetic grafts are more appropriate for this indication.

Analysis of our experiences with PCB leads to two main conclusions. First, indications for carotid bypass grafting are uncommon, accounting for fewer than 10% of carotid revascularization procedures. Second, PCB with PTFE grafts is a viable and reliable alternative to CEA in selected patients.

REFERENCES

1. European Carotid Surgery Trialist's Collaborative Group MRC. European carotid surgery trial: interim results for symptomatic patients with severe (70-90%) or with mild (0-29%) carotid stenosis. Lancet 1991; 337:1235-43.
2. Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. JAMA 1995;273:1421-8.
3. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. N Engl J Med 1991; 325:445-53.
4. Branchereau A, Ondo N'Dong F, Bordeaux J, Sambuc R. Neurologic complications following carotid artery surgery: pathophysiology and predictive factors. Ann Vasc Surg 1986;1:79-85.
5. Ouriel K, Green RM. Clinical and technical factors in endarterectomy. J Vasc Surg 19875:702-6.
6. Sawchuk AP, Flanigan DP, Machi J, Schuler JJ, Sigel B. The fate of unrepaired minor technical defects detected by intraoperative ultrasonography during carotid endarterectomy. J Vasc Surg 1989;9:671-6.
7. Sundt TM, Sundt JR. Carotid venous grafts. J Neurosurg 1987;66:174-80.
8. Clagett GP, Patterson CB, Fisher DF Jr, Fry RE, Eidt JF, Humble TH, et al. Vein patch versus primary closure for carotid endarterectomy: a randomized prospective study in a selected group of patients. J Vasc Surg 1989;9:213-23.
9. Eikelboom BC, Ackerstaff RG, Hoeneveld H, Ludwig JW, Teeuwen C, Vermeulen FE, et al. Benefits of carotid patching: a randomized study. J Vasc Surg 1988;7:240-7.
10. Hertzer NR, Beven EG, O'Hara PJ, Krajewski LP. A prospective study of vein patch angioplasty during carotid endarterectomy. Three-year result for 801 patients and 917 operations. Ann Surg 1987;206:628-35.
11. Kieny R, Hirsch D, Seiller C, Thiranos JC, Petit H. Does carotid eversion endarterectomy and reimplantation reduce the risk of restenosis? Ann Vasc Surg 1993;7:407-13.
12. Lord RS, Raj TB, Stary DL, Nash PA, Graham AR, Goh KH. Comparison of saphenous vein patch, polytetrafluoroethylene patch, and direct arteriotomy closure after carotid endarterectomy. Part l: Perioperative result. J Vasc Surg 1989;7:521-9.
13. Sandmann W, Willeke F, Kolvenbach R. To shunt or not to shunt: the definite answer with a randomized study. In: Veith F, editor. Current critical problems. Vol 5, St Louis, MO: Quality Medical Publishing; 1993, p 434-40.
14. Cormier JM, Laurian C, Gigou F, Franceschi C, Luizy F. [Venous graft versus carotid thromboendarterectomy.] J Mal Vasc 1982;7:25-31. (French)
15. Green RM, Greenberg R, Illig K, Shortell C, Ouriel K. Eversion endarterectomy of the carotid artery: technical considerations and recurrent stenoses. J Vasc Surg 2000;32:1052-61.
16. Ouriel K, Greenberg RK, Sarac TP. Hemodynamic conditions at the carotid bifurcation during protective common carotid occlusion. J Vasc Surg 2001;34:577-80.
17. Fabiani JN, Julia P, Chemla E, Birnbaum PL, Chardigny C, D'Attellis N, et al. Is the incidence of recurrent carotid artery stenosis influenced by the choice of the surgical technique? Carotid endarterectomy versus saphenous vein bypass. J Vasc Surg 1994;20:821-5.
18. Branchereau P, Pietri P, Magnan PE, Rosset E. Saphenous vein bypass: an alternative to internal carotid reconstruction. Eur J Vasc Endovasc Surg 1996;12:26-30.
19. Cormier JM, Brisset D, Speir Y, Galiardo G, Marzelle J, Laurian C, et al. [Fifty-three atherosclerotic carotid stenoses in an irradiated environment.] J Mal Vasc 1993;18:269-74. (French).
20. Cormier JM, Chapelier A. Résultats tardifs de la revascularisation par greffe veineuse des sténoses athéroscléreuses de la carotide interne. In:

Kieffer E, Bousser MG, editors. Indications et résultats de la chirurgie carotidienne. Paris, France: AERCV; 1988. p 101-15.
21. Cormier JM, Cormier F, Laurian C, Gigou F, Fichelle JM, Bokobza B. Polytetrafluoroethylene bypass for revascularization of the atherosclerotic internal carotid artery: late results. Ann Vasc Surg 1987;1:564-71.
22. Archie J. The endarterectomy-produced common carotid artery step: a harbinger of early emboli and late restenosis. J Vasc Surg 1996;23:932-9.
23. Gelabert HA, Moore WS. Carotid restenosis. In: Whitemore AD, editor. Advances in vascular surgery. St Louis, Mo: Mosby; 1994. p 171-93./
24. Ward AS, Cormier JM. Internal carotid bypass. In: Ward AS, Cormier JM, editors. Operative techniques in arterial surgery. Lancaster, England: MTP Press; 1986. p 236-9.
25. Piepgras DG, Sundt TM Jr, Marsh WR, Mussman LA, Fode NC. Recurrent carotid stenosis: results and complications of 57 operations. Ann Surg 1986;203:205-13.
26. Gagne PJ, Riles TS, Jacobowitz GR, Lamparello PJ, Giangola G, Adelman MA, et al. Long-term follow-up of patients undergoing reoperation for recurrent carotid artery disease. J Vasc Surg 1993;18:991-1001.
27. Berguer R, Kline RA. Artères carotides. In: Kieffer E, ed. Le remplacement artériel: principes et applications. Paris, France: AERCY; 1992, p 367-75.
28. Raithel D. Choice of graft material in carotid surgery: vein vs. PTFE. In: Veith FJ, editor. Current critical problems in vascular surgery, Vol 6, St Louis, Mo: Quality Medical Publishing; 1994. p 259-63.
29. Sise MJ, Ivy ME, Malanche R, Ranbarger KR. Polytetrafluoroethylene interposition grafts for carotid reconstruction. J Vasc Surg 1992;16: 601-8.
30. Moore WS, Martello JY, Quinones-Baldrich WG, Ahn SS. Etiologic importance of the intimal flap of the external carotid artery in the development of postcarotid endarterectomy stroke. Stroke 1990;21: 1497-502.
31. Riles TS, Imparato AM, Jacobowitz GR, Lamparello PJ, Giangola G, Adelman MA, et al. The cause of perioperative stroke after carotid endarterectomy. J Vasc Surg 1994;19:206-16.

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See Invited Commentary on page 1042.